July 15, 2019

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Expanding Flexible Use of the 3.7 GHz Band
GN Docket No. 18-122
Joint Ex Parte Presentation

The Wireless Internet Service Providers Association ("WISPA"), Google LLC and Microsoft Corp. share the goal of bringing better broadband to more consumers, especially those millions of Americans that lack adequate fixed broadband in their homes, small businesses, farms, ranches, and other locations. To help achieve these objectives, each of us has participated in this proceeding asking that the Commission make the 3700-4200 MHz band available for Part 101 frequency coordinated point-to-multipoint ("P2MP") operations.

Previously, the Broadband Access Coalition, in conjunction with Google, conducted initial technical inquiries to determine if P2MP systems could offer fixed wireless broadband access services on a shared basis in 300 megahertz of the C-band, while not causing harmful interference to incumbent fixed-satellite service ("FSS") earth stations in the band. Our inquiry focused on *co-channel* sharing, and therefore did not assume any frequency separation between fixed services and FSS. Instead, the concept relied upon a combination of geographic separation and FSS-aware network planning of the P2MP systems such that any fixed wireless signals reaching FSS sites were below harmful interference thresholds. The results of this initial inquiry were shared with the Commission.[1]

To confirm and demonstrate the possibility and opportunity of shared access to the C-band by both FSS and P2MP users, WISPA, Microsoft, and Google commissioned a third-party technical study to expand the scope of the original inquiry to include the new registrations, and to independently verify the technical results of that inquiry. The Joint Commenters engaged Professor Jeff Reed, the Willis G. Worcester Professor of Electrical and Computer Engineering at Virginia Tech and the founding director of Wireless @ Virginia Tech, to perform an independent analysis of the feasibility of *co-channel* sharing between FWA and FSS earth stations in C-band. The results of that study conducted by Professor Reed and his colleagues are summarized in the presentation attached to this filing. This report, which relies on conservative estimates and standards-based assumptions, shows that earth stations can be coordinated and

[1] *See* Letter from Stephen E. Coran to Marlene H. Dortch, FCC Secretary, RM-11791 (filed March 28, 2018).

protected within a geographic exclusion zone of less than 10 km. In turn, this means that more than 80 million Americans and 78% of the geographic area of the country will have the ability to access currently fallow spectrum for P2MP services. The greatest availability will be in rural areas where earth stations are less prevalent and widely dispersed. The complete report is attached.

With a sufficient amount of new mid-band spectrum, broadband providers can deploy networks capable of offering gigabit or near-gigabit broadband service. Significantly, this opportunity is complementary to proposals to reallocate some of the C-band for flexible use. In sum, the Commission can clear 200 megahertz for flexible use, re-pack earth stations from that band in the upper 300 megahertz, and allow shared, coordinated use of the upper 300 megahertz among FSS and P2MP.

The following conclusions of the study, and related points, deserve particular emphasis.

1. **P2MP in shared C-band spectrum can provide gigabit broadband access for more than 80 million Americans.** The C-band Alliance supports clearing and auctioning up to 200 megahertz out of 500 megahertz of C-band spectrum for flexible use.[2] At least 300 megahertz of spectrum would be used by C-band earth stations repacked into the remaining spectrum. Assuming a conservative overall average of 4 bits/second/hertz spectral efficiency, 300 megahertz of C-band spectrum would allow gross throughput rates of approximately 1.2 gigabits per second for P2MP systems. For comparison, 300 megahertz of spectrum is some *six times* greater than the maximum amount of spectrum currently available for wireless ISPs in the 3.65 GHz band today, and twice as much spectrum than is available in the entire CBRS band.

2. **P2MP will not cause harmful interference to co-channel FSS.** As the attached study shows, P2MP systems can operate *co-channel* with all existing C-band earth stations (including the ~14,000 additional earth stations that were recently registered), without causing harmful interference. This is the result of employing reasonably-sized exclusion zones surrounding earth stations, combined with siting and pointing of P2MP nodes such that no signals exceeding Commission-declared interference criteria are received at any FSS earth station. Part 101 coordination would calculate and determine actual co-channel geographic exclusion zones.

3. **Repacking C-band will have no effect on the results of the study.** The coexistence study already assumes that the P2MP systems are operating *co-channel* with FSS. Repacking FSS to a smaller portion of the original C-band results in greater concentration of earth station use in the repacked frequencies, but such concentration does not matter to the results of the study. Co-channel sharing with all 18,000+ earth stations has *already been assumed*. The only criterion that matters to the results of the study is the location of the earth stations.[3]

[2] https://c-bandalliance.com/?utm_campaign=marketing

[3] We note, however, that if the study had considered *non-co-channel* use, the results would likely be even more dramatic. If the Commission agrees to prohibit "full-band, full-arc" registrations for the vast

4. **All C-band registrations have been taken into account, including those that have yet to be accepted by the Commission.** The study assumes that all 18,000+ registrations in the International Bureau Filing System (IBFS) as of the close of the registration window are legitimate registrations, although a large number have yet to be accepted by the Commission. Among the many conservative assumptions in the study, coexistence registrations that are not accompanied by coordination reports, which are not afforded interference protection from co-primary fixed services,[4] are included in the analysis.

5. **The study utilizes conservative assumptions.** In addition to the assumption of co-channel operations and the protection of all earth stations currently in IBFS regardless of protection status, the study includes additional conservative assumptions. These include, but are not limited to, a propagation model that takes clutter and terrain into account on a statistical basis rather than the use of actual buildings, trees, berms, hills, and mountains that afford greater protection; using a height for Customer Premise Equipment (CPE) of 7-10 m, which exceeds typical CPE height of ~5-7 m for actual installations; and assuming 100% duty cycle of P2MP transmissions in both directions.

6. **P2MP will better protect adjacent-band radio altimeter operations.** Concern has been expressed regarding the impact of C-band transmissions on the proper operation of radio altimeters for aeronautical navigation, which are employed in the central 100 MHz of the adjoining 4200-4400 MHz band.[5] Because radio altimeters are primarily used at elevations of 5000 feet or less on approach to airports, the same methods used by P2MP systems to avoid beaming energy toward FSS can be employed to avoid deploying P2MP near approach paths or beaming P2MP signals toward airport facilities. Further, P2MP base and CPE antennas are specifically designed with narrow vertical beams, and the base transmissions are often downtilted toward surrounding service areas, so that P2MP systems by design suppress emissions in the upward direction. Flexible use systems, on the other hand, include mobile stations, which typically involve omnidirectional antennas with no control over the orientation of the antenna, thereby increasing the risk that interfering signals may be sent upward toward aircraft. In fact, the band that is adjacent to the upper end of the radio altimeter band, i.e, the 4400-4500 MHz band, is a federal band that is used for fixed service transmissions,[6] underscoring the ability of the radio altimeter stations in 4200-4400 MHz to coexist peacefully with fixed systems in the adjoining band.

---

majority of C-band earth stations that don't require it, we can re-do the study to show even greater broadband penetration.

[4] *Public Notice*, GN Docket No. 18-122, RM-11791, RM-11778, DA 19-385 (rel. May 3, 2019) at 4 ("Registrations or licenses granted for applications filed during the window without the coordination report will include a condition noting that the license or registration does not afford interference protection from fixed service transmissions.")

[5] *See* Letter from Aviation Associations to Marlene H. Dortch, FCC Secretary, GN Docket No. 18-122 (filed June 19, 2019).

[6] There are 882 federal fixed (point-to-point) systems in this band compared to only 16 federal mobile systems. *See* the National Telecommunications and Information Administration Band Use Report for this band, *available at* https://www.ntia.doc.gov/files/ntia/publications/compendium/4400.00-4500.00_01DEC15.pdf.

7. **P2MP will have no effect on flexible use operations in the lower part of the band.** The same guard band that will protect earth stations from flexible use operations in the lower part of the 3700-4200 MHz band will also work as a guard band between those flexible use systems and P2MP systems in the upper portion of the band. In fact, it's likely that no guard band is actually needed to protect flexible use and P2MP use, given that there will be no guard band at all between flexible use systems operating within the lower 200 megahertz of the band. If flexible use systems can co-exist with themselves with 0 MHz of guard band given that they will include mobile systems operating with no constraints on antenna orientation, then they should co-exist perfectly with P2MP systems, which employ only fixed and carefully-pointed antennas, without any guard band.

As noted in the study, the analysis is based on a statistical average and is intended for the baseline performance and for estimating the national coverage. In practice, each P2MP system would be designed and coordinated on a site-specific basis, taking all surrounding earth stations into account, and fully protecting those operations.

Based on the foregoing findings and conclusions, FSS earth stations operating in the 3700-4200 MHz band should be entitled to coordinated protection from harmful interference predicted to be caused by co-primary, co-channel terrestrial fixed operations, such as P2MP broadband services, operating in the same band. As the attached coexistence report demonstrates, such protections are possible even when FSS operations are re-packed in the upper portion of C-band. P2MP systems in this band operating on a shared basis with FSS earth stations will provide gigabit-class broadband services to more than 80 million Americans, without causing harmful interference to FSS. As part of the C-band proceeding, and as proposed in the NPRM, the Commission should authorize shared use of the band for this important national objective.

Respectfully submitted,

**WIRELESS INTERNET SERVICE PROVIDERS ASSOCIATION**

By: */s/ Claude Aiken*
Claude Aiken, President & CEO

**GOOGLE LLC**

By: */s/ Andrew Clegg*
Andrew Clegg, Spectrum Engineering Lead

**MICROSOFT CORP.**

By: */s/ Michael Daum*
Michael Daum, Technology Policy Strategist, Regulatory Affairs

Attachment: Technical Study by Professor Reed and colleagues, Reed Engineering

# 3.7-4.2 GHz FSS and Fixed Wireless Access Co-channel Coexistence Study

Prof. Jeffrey H. Reed
Dr. Nishith Tripathi
Sahana Raghunandan

Reed Engineering

July 2019

Study Sponsors:

WISPA Microsoft Google

# Improving Spectrum Utilization

"We no longer have the luxury of over-protecting incumbents via technical rules, enormous guard bands, or super-sized protection zones. Every megahertz must be used as efficiently as possible."

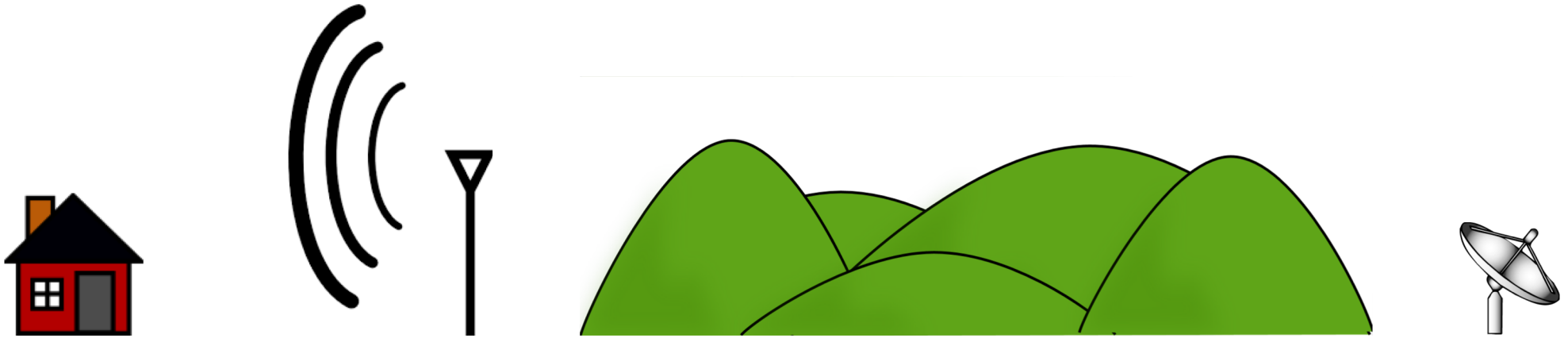
– *FCC Commissioner Michael O'Rielly*

Speaking at Wi-Fi Alliance, Washington D.C., June 4th 2019

# Executive Summary

Exclusion zones of about 10 km are sufficient to protect most fixed-satellite service (FSS) earth stations from harmful interference caused by properly-engineered co-channel point-to-multipoint (P2MP) broadband systems.

P2MP systems operating outside the exclusion zones could provide gigabit broadband access to more than 80 million Americans, particularly those in underserved communities.



# Inputs & Key Assumptions

FCC database of 18,000+ FSS earth stations subsequent to 2018 registration filing window.

FCC FSS antenna gain pattern envelope.[1]

FCC FSS interference criterion[2] (same co-channel criterion used for CBRS).

Industry-standard (3GPP/ITU-R) rural macro non-line-of-sight propagation model.[3]

Nominal point-to-multipoint broadband system architecture

- 80 W base station (BS) and 20 W Customer Premise Equipment (CPE) effective radiated power per 20 MHz
- 35 m BS and 7 m CPE antenna height
- Industry-standard (3GPP) antenna model[4]

*Co-channel* operation of P2MP and FSS

Sensitivity analysis performed by varying base station (BS) antenna height, number of BSs, Customer Premise Equipment (CPE) transmit power, number of CPEs, and FSS receiver antenna height

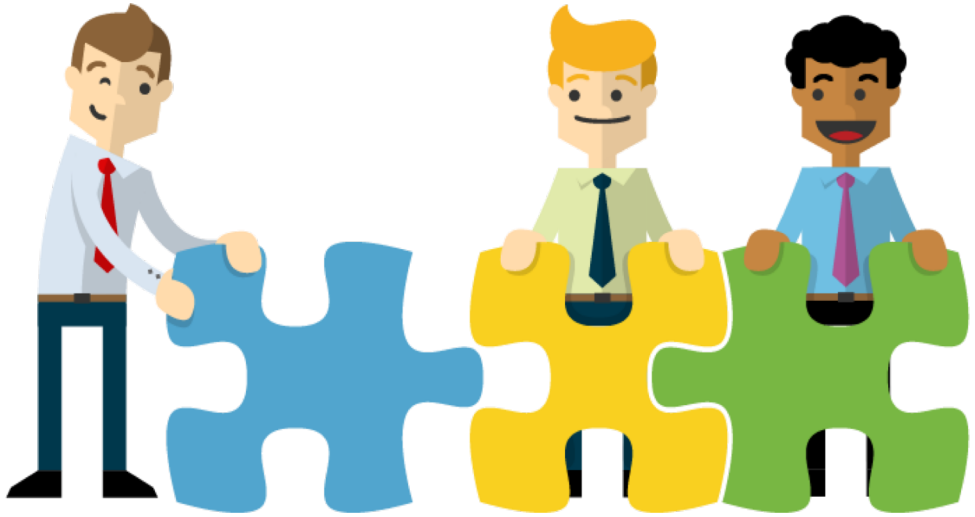
Actual P2MP deployments would be carefully coordinated under Part 101 against all FSS earth stations

[1] 47 CFR 25.209(a)(1)
[2] -129 dBm/MHz based on 47 CFR 96.17(a)(2)
[3] ITU-R M.2135
[4] 3GPP TR 36.873, v12.5.0

# Outline

- Describe the co-channel coexistence scenario between Fixed-Satellite Service (FSS) and Point-to-Multipoint (P2MP) Fixed Wireless Access in the 3.7-4.2 GHz range
- Explain single-system analysis and large-scale analysis
- Summarize key findings of the study

# FSS-P2MP Coexistence

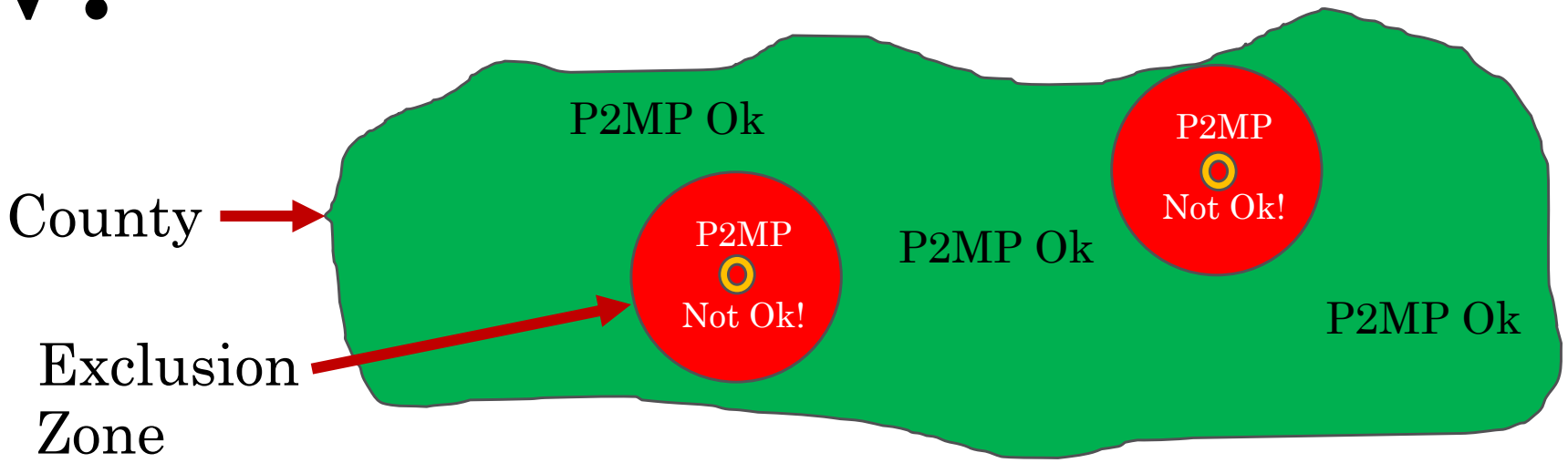


# Sharing the 3.7-4.2 GHz Spectrum

Provide P2MP broadband access in shared C-band spectrum while protecting the incumbent FSS earth stations

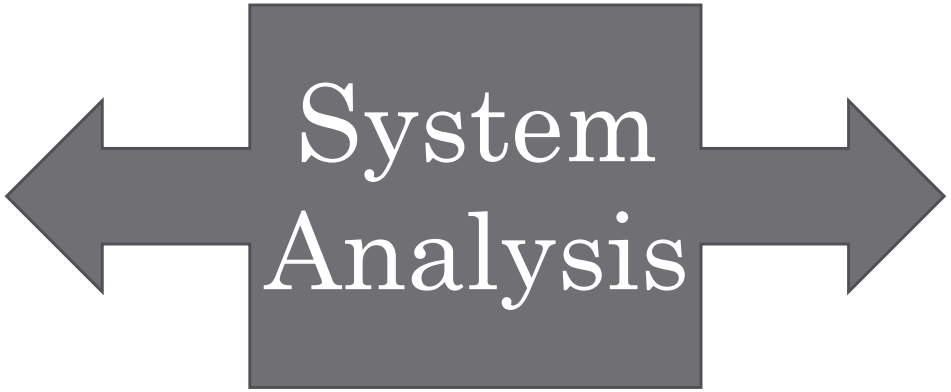
**How?**

**<u>Answer</u>**: Determine the exclusion zone around an FSS earth station based on detailed **co-channel interference** analysis!



# Single-System and Large-Scale Analysis

# Types of Analysis




**Single-System Analysis**

- One FSS earth station

**Large-Scale Analysis**

- All FSS earth stations in the country

# Single-System Analysis: Goal and Example Scenarios

Goal: Determine the radius of the co-channel exclusion zone around an FSS earth station to provide harmful interference protection from P2MP transmitters

- One P2MP Base Station (BS) co-channel with FSS
- Multiple co-channel P2MP BSs
- One P2MP co-channel Customer Premise Equipment (CPE) device
- Multiple co-channel P2MP CPEs
- Sensitivity Analysis
  - Propagation model, P2MP BS antenna height, number of P2MP BSs, device EIRP, number of P2MP BSs, number of CPEs

***Note:*** This study uses the CBRS-to-FSS interference protection criterion where the total received co-channel interference is below -129 dBm/MHz

# Single-System Analysis: Two Approaches


**Analytical Approach**

**Simulation Approach**

Formulas in spreadsheet

Modeling in MATLAB

Easier Sensitivity Analysis

Closer to Reality

Sanity Check

Sanity Check

# Single-System Analytical Approach Procedure

Determine a suitable propagation model
(Please see the next slide)

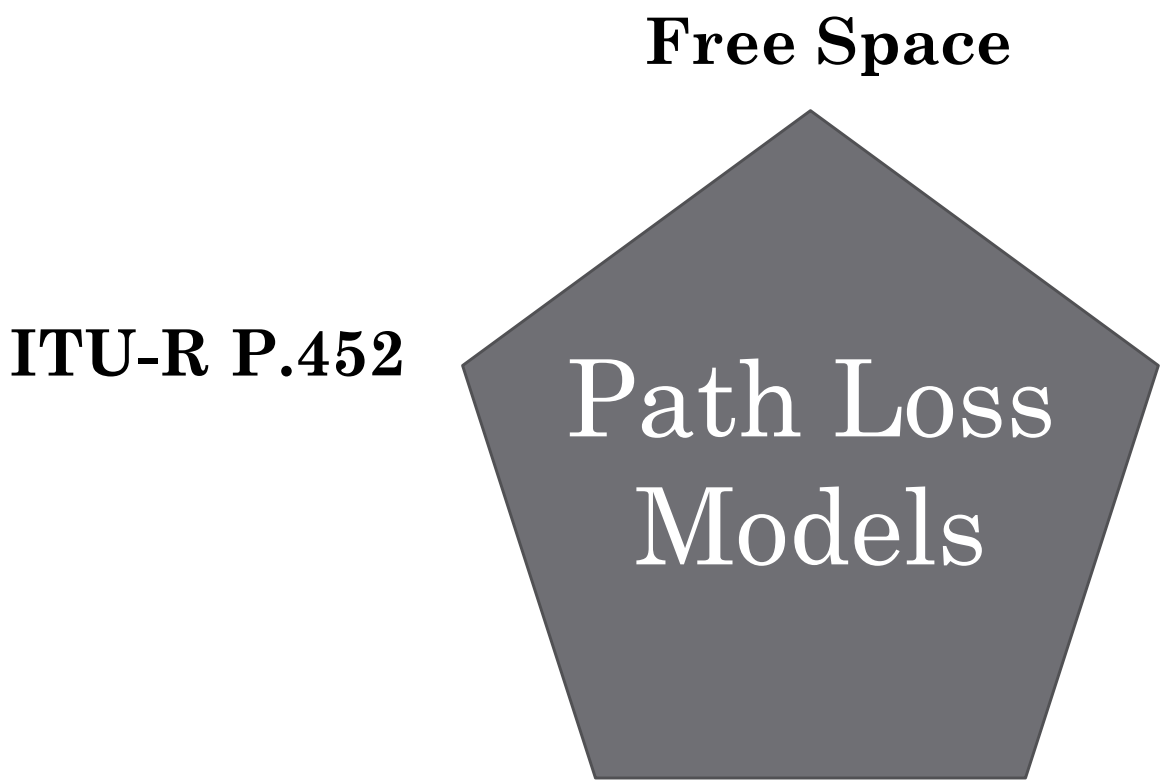
↓

Calculate the radius of the co-channel exclusion zone

↓

Carry out the sensitivity analysis
(P2MP BS antenna height, number of P2MP BSs,
CPE transmit power, number of CPEs)

# Propagation Models Considered




➢ **Most applicable to this study**

# Propagation Model: Key Points

Propagation models are key to any interference analysis.

We chose a non-line-of-sight model because it better reflects reality; terrain and obstructions will almost always separate P2MP systems from FSS earth stations.

The 3GPP TR38.901 model predicts less than a 0.0046% chance of having a completely unobstructed path over a distance of 10 km or greater.

This model is consistent with a large number of propagation loss measurements obtained in the immediately-adjacent CBRS band: "clutter" adds approximately 40-60 dB over terrain-based propagation models.[1]

[1] See *Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Docket 12-354, comments of Google Inc., filed Feb 16, 2016; specifically Fig. 4 of Clegg Declaration. Document available at https://ecfsapi.fcc.gov/file/60001462642.pdf

# Why Should We Assume Non-Line-of-Sight?

## 3GPP LOS/NLOS Probability Model (3GPP TR38.901)

The probability of LOS propagation is:

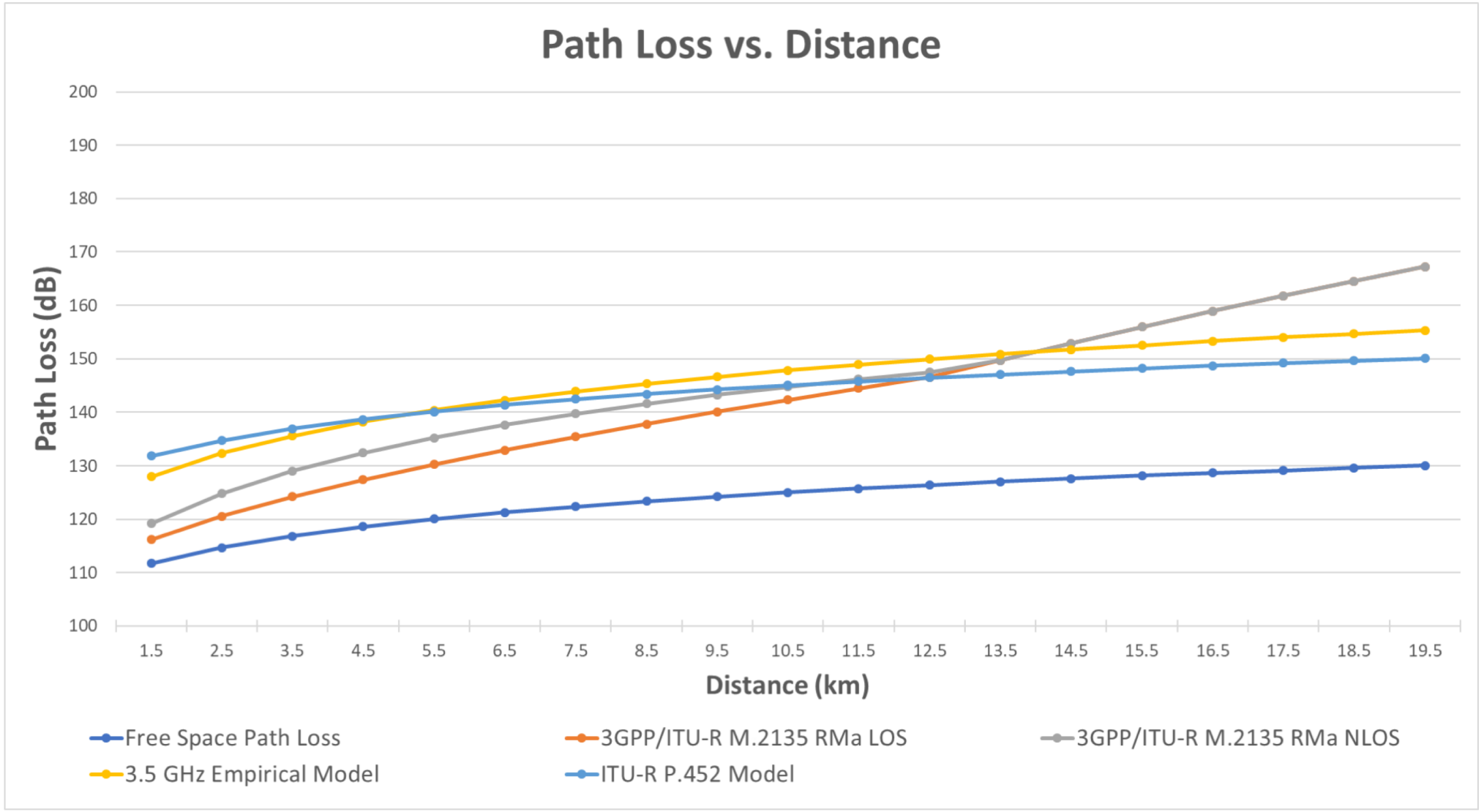
$$\Pr(LOS) = 1 \text{ for } d \leq 10\ m$$
$$= e^{-\left(\frac{d-10}{1000}\right)} \text{ for d} > 10 \text{ m}$$

D: Distance between the transmitter and the receiver (m)

- Example: For an exclusion zone radius of 10 km, the probability of NLOS propagation is 99.995%, virtually guaranteeing NLOS propagation even in an open rural environment
- Think about local clutter near the FSS earth station and propagation path between P2MP transmitter and FSS earth station: Terrain, trees, bridges, gas stations, churches, residences, water towers, barns, restaurants, silos, berms, … (the list goes on)!

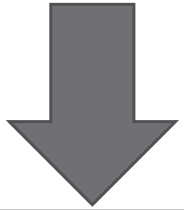
➢ **A non-line-of-sight model is the most realistic choice**

# Path Loss (BS and FSS Heights: 35 m and 5 m)

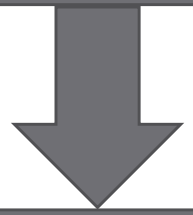


# Single-System Simulation Approach Procedure

Design the deployment layout to model P2MP transmitters around an FSS earth station and configure the simulation with suitable P2MP and FSS parameters such as antenna patterns and antenna pointing



Uniformly distribute P2MP BSs or CPEs in the P2MP coverage area as interferers to the centrally-located FSS earth station receiver and calculate the total interference



Determine the exclusion zone that ensures the total interference stays below the target threshold

# Large-Scale Analysis: Goal and Key Components

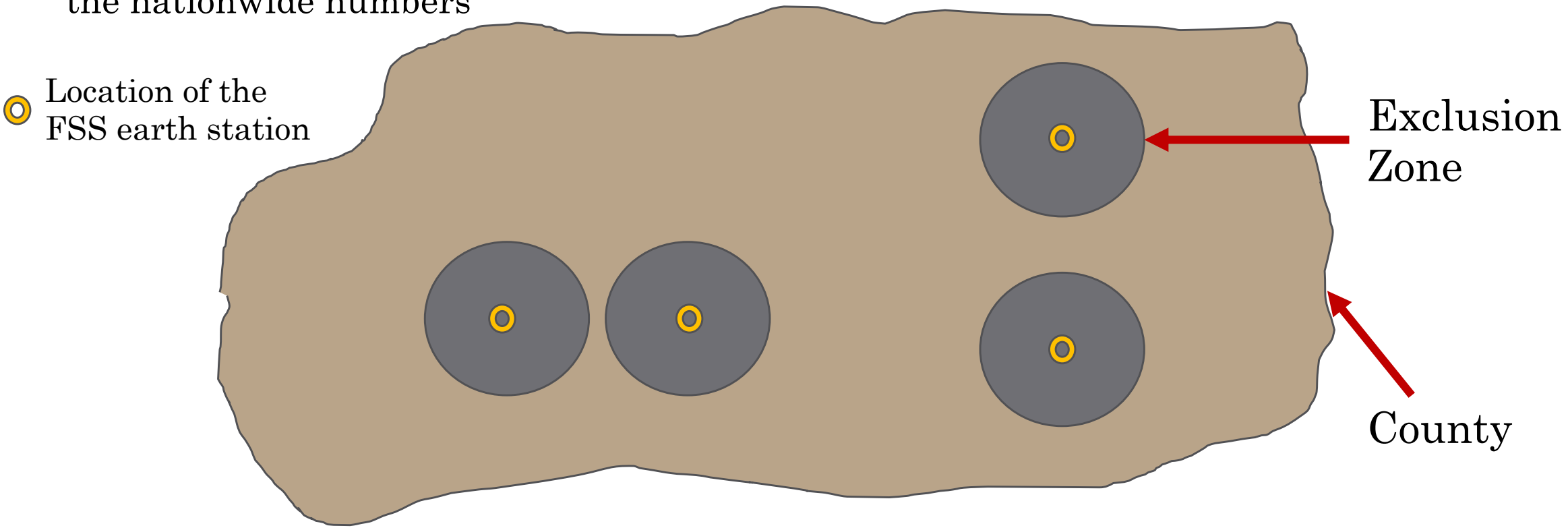
Goal: Through a nationwide analysis, determine the geographic area and the number of Americans benefitting from P2MP broadband services, without causing harmful interference to any FSS earth stations

**Key Components**

- Multiple databases based on the latest (2010) U.S. Census Data (e.g., county-based land area and population density)
- Google API to associate the FSS earth station with the correct county
- Custom scripts to clean up FSS data (e.g., missing or suspect), and to perform suitable calculations
- Make use of the exclusion zone radius determined by the single-system analysis
- High-level analysis and refined analysis (please see the next 2 slides)

# Large-Scale Analysis: High-Level

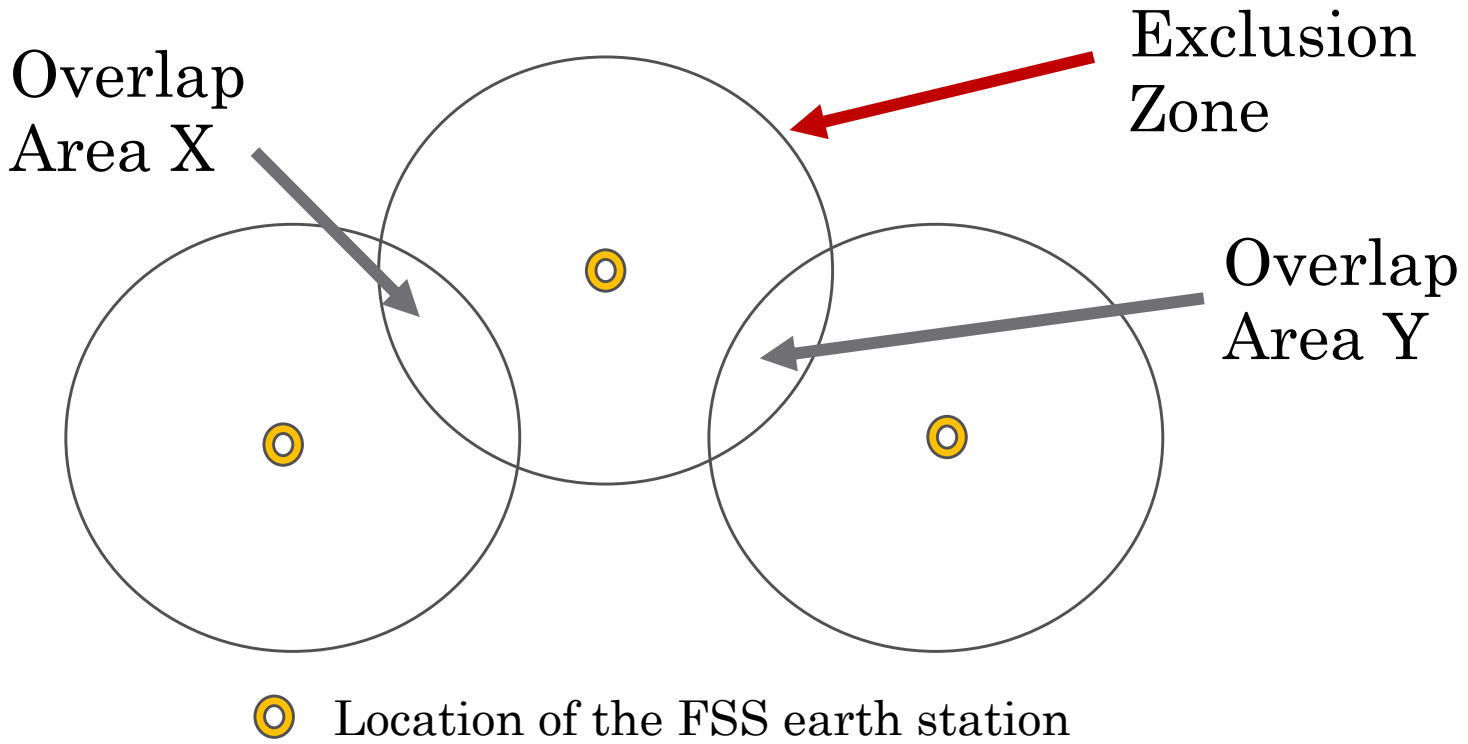
- Assumption: Exclusion zones around FSS earth stations do not overlap
- P2MP Service Area = (Total County Land Area) – (Total Exclusion Zone Area)
- # of people who can be served = (P2MP Service Area) * (Population Density)
- Carry out county-based analysis and add county-based service areas and population for the nationwide numbers




*Note:* Since any overlap among the FSS earth stations is ignored, this high-level analysis underestimates the geographic area and the population benefitting from P2MP broadband service.

# Large-Scale Analysis: Refined

- Refinement over high-level analysis: Consider any overlap among a set of exclusion zones
- More accurate results compared to the high-level analysis
- Example:
  - Approximate exclusion zone = 3*A, where A is the area of the exclusion zone for one FSS earth station in a county
  - Refined exclusion zone = approximate exclusion zone – overlap area X – overlap area Y



# Key Analysis Considerations

FSS earth stations point upwards towards satellites. They are specifically designed to mitigate their response to signals arriving from the horizon (i.e., from terrestrial P2MP links). The FCC's FSS beam pattern envelope [47 CFR 25.209(a)(1)] takes this into account and was used in this study.

P2MP antennas are directional and are designed to place energy where it's desired (toward customers), and to greatly reduce emissions in directions where they are not desired (toward earth stations). The 3GPP beam pattern, used in this study, takes this into account.

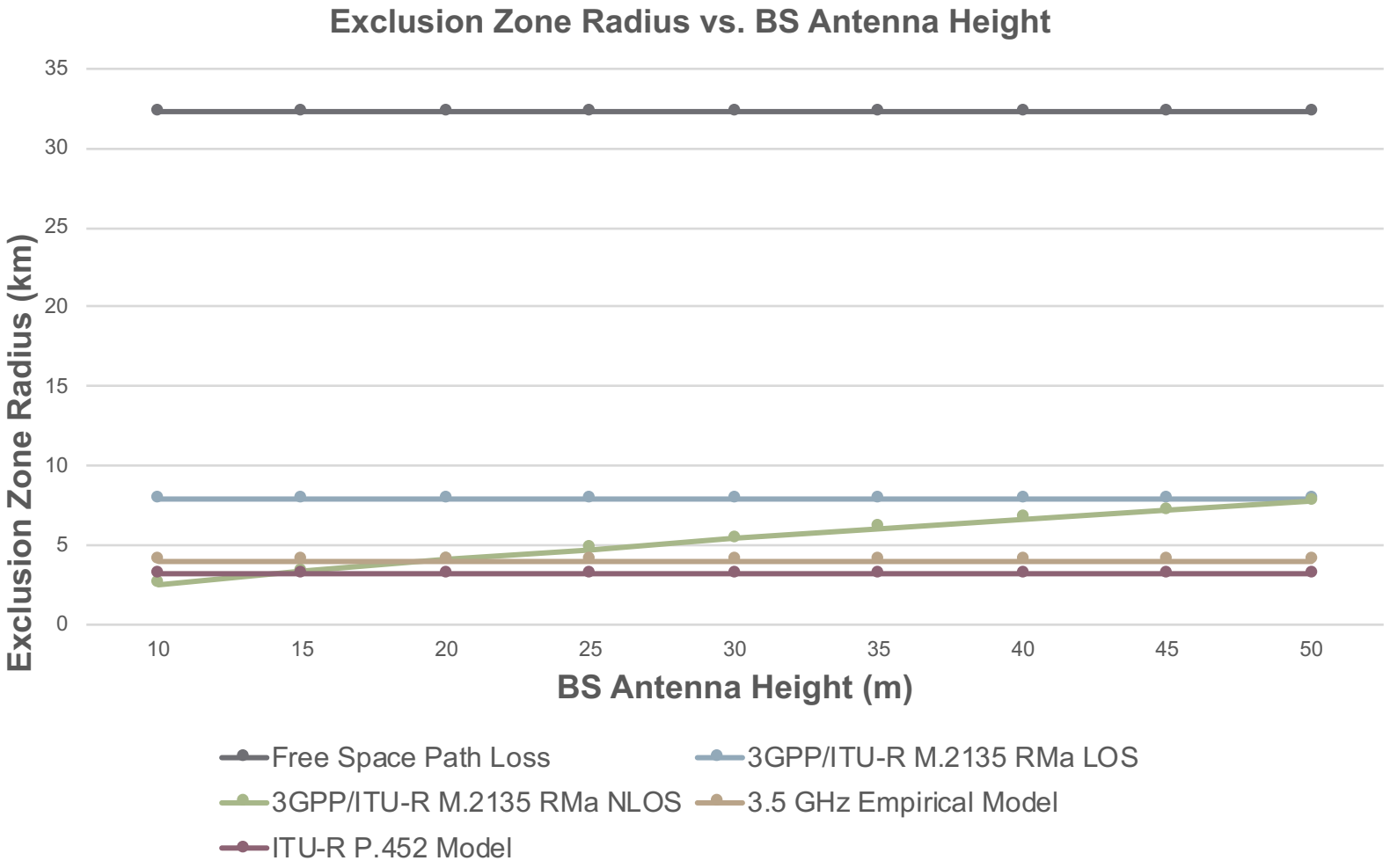
Clutter (buildings, trees, etc.) will greatly reduce the strength of any stray signals arriving at earth stations due to P2MP emissions. The propagation model used in this study takes that into account.

# Findings of the Analysis

# Key Parameters (Analytical Approach)

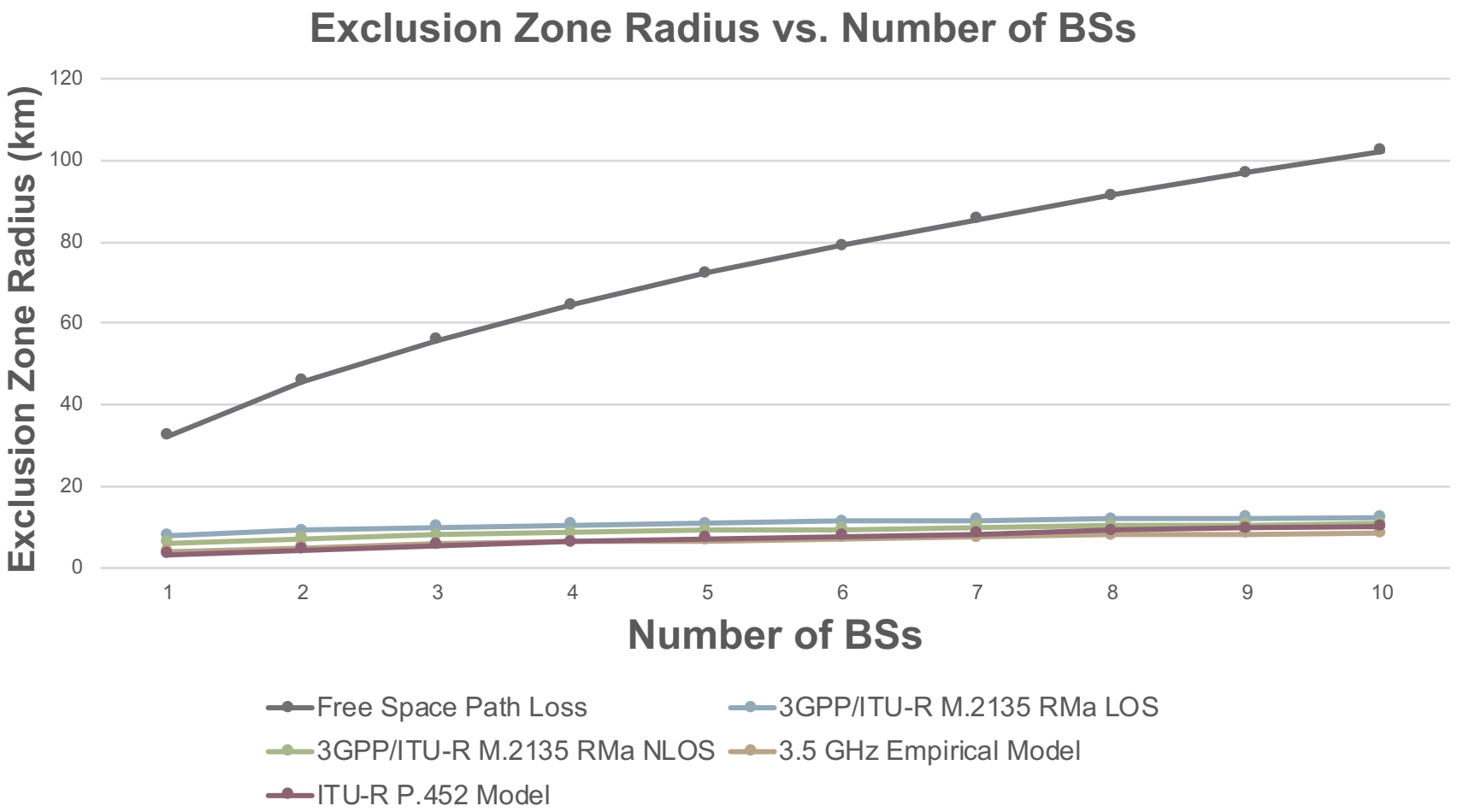
| Parameter | Numerical Setting | Comments |
|---|---|---|
| Channel Bandwidth | 20 MHz | |
| P2MP BS antenna height | 35 m | Sensitivity analysis carried out for the 10 - 50 m range |
| P2MP BS Max EIRP toward FSS earth station receiver | 28 dBm (15 dBm/MHz) | 49 dBm EIRP - 21 dB transmit antenna attenuation toward FSS earth station Rx = 28 dBm |
| CPE Tx EIRP toward earth station receiver | 23 dBm (10 dBm/MHz) | Sensitivity analysis carried out for the 17 dBm to 43 dBm range to reflect fixed P2MP device specifications |
| CPE Antenna Height | 7 m | Typical CPE height (outdoor) |
| FSS earth station receive antenna height | 5 m | Lower heights will experience less interference |
| FSS earth station receiver antenna gain toward the P2MP transmitter (dBi) | -10 dBi | For off-axis angles greater than 48 degrees in accordance with 47 CFR 25.209(a)(1) |
| Number of BSs | 1 | Sensitivity analysis carried out for 1 to 10 |
| Number of CPEs | 1 | Sensitivity analysis carried out for 1 to 300 |

# Impact of the BS Antenna Height on the Exclusion Zone



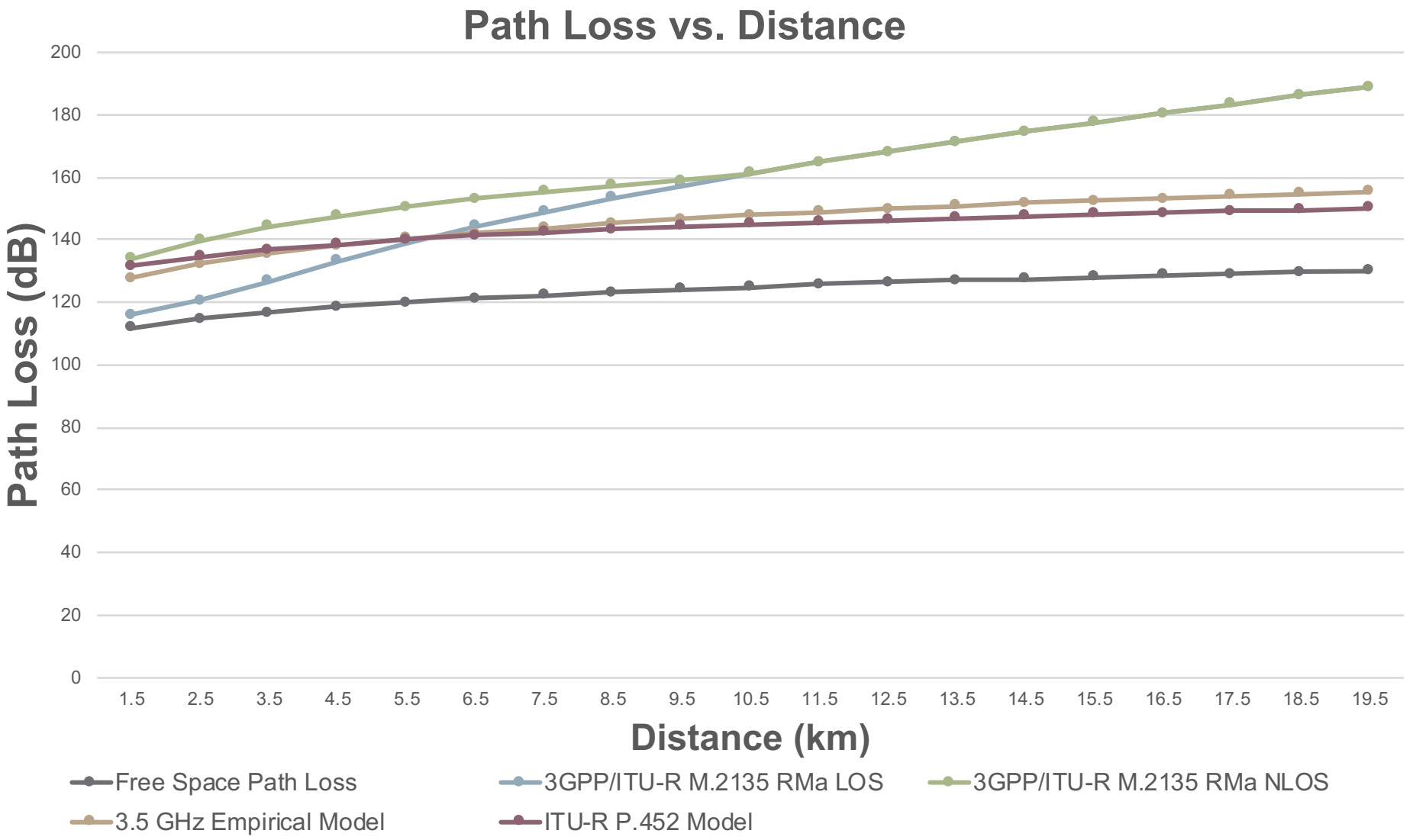

- For the 10 m to 50 m range of the BS antenna height (and 5 m FSS earth station height), the BS antenna height influences the size of the exclusion zone (Validity: NLOS model only)
- For *a single P2MPS BS*, the exclusion zone radius is **6 km** for the BS height of 35 m.

# Impact of the Number of BSs on the Exclusion Zone



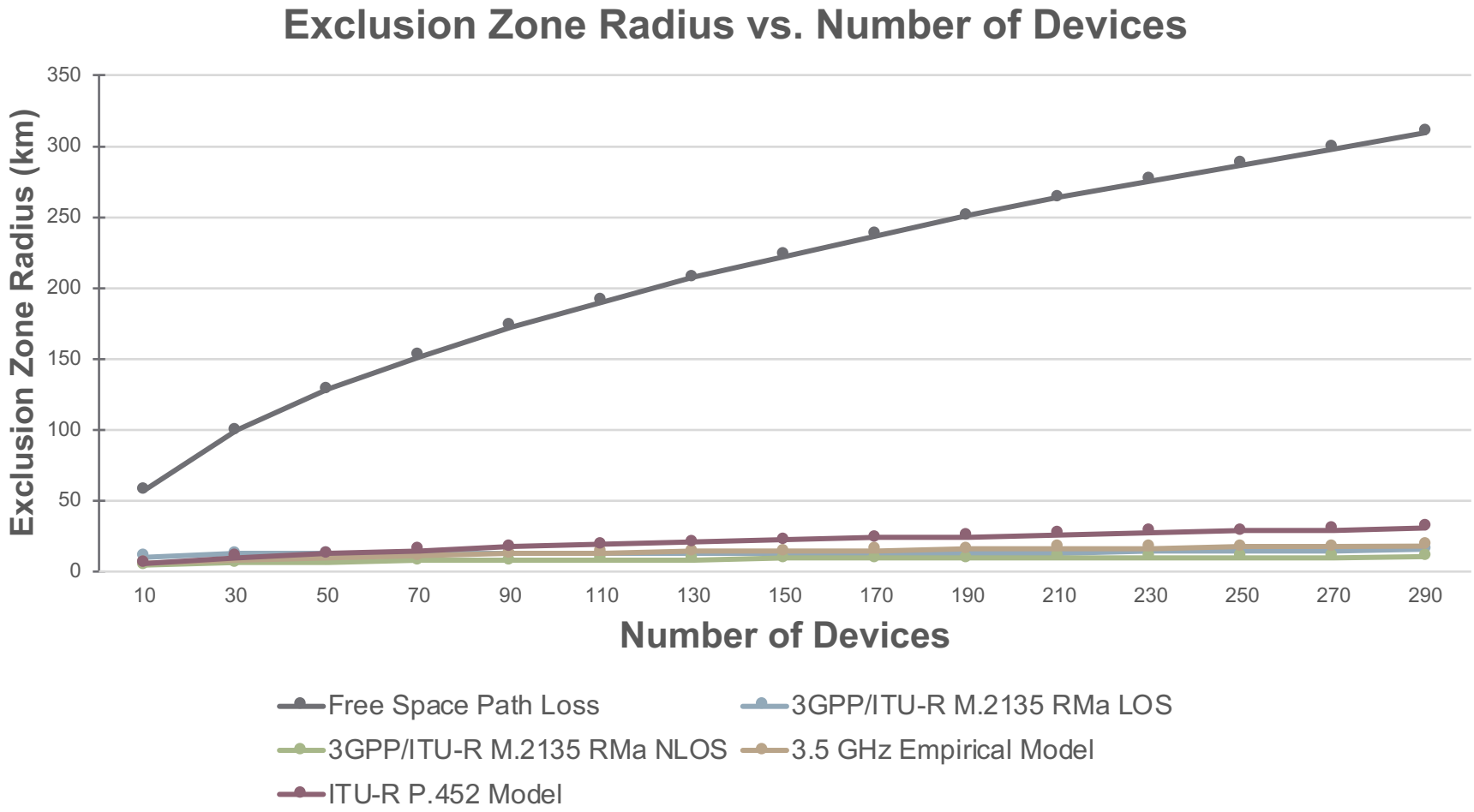

- Even for the near-contiguous P2MP coverage surrounding the FSS earth station (i.e., 6 P2MP BSs), the exclusion zone radius would be less than 10 km (**9.6 km** for the NLOS model) (BS antenna height = 35 m and FSS antenna height = 5 m)
- Practical P2MP deployments are unlikely to fully surround an FSS earth station

# Impact of a CPE Transmitter on the Exclusion Zone



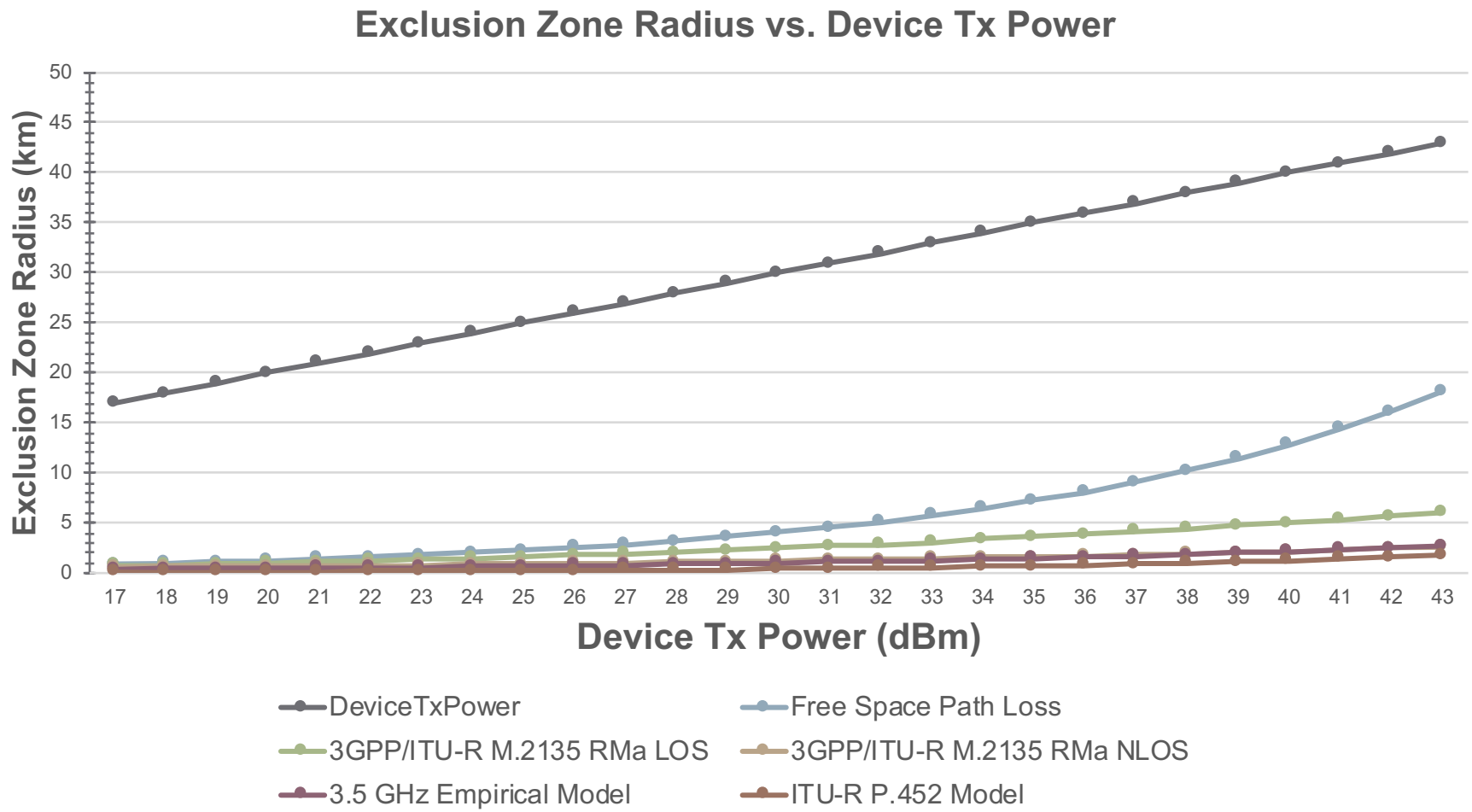

- The path loss is higher in case of the CPE transmitter because of the lower antenna height (Ex: 157 dB for the CPE Tx – 143 dB for the BS Tx = 14 dB difference at ~10 km for the NLOS model)

# Impact of the Number of CPEs on the Exclusion Zone




- Even for *simultaneous full-power transmissions from 300* CPEs, an exclusion zone of **less than 10 km** would be adequate to protect the FSS earth station receiver in realistic scenarios
- Since P2MP deployments are not blanket deployments and since the CPE density is low in rural environments, a 10 km exclusion zone is more than adequate to protect the FSS receivers

# Impact of the CPE Tx Power on the Exclusion Zone




- Typical fixed device: 40 dBm EIRP - 20 dB attenuation toward an FSS Rx (Net EIRP: 20 dBm)
- Exclusion zone radii: 2 km for the 40 dBm high-power CPE in realistic NLOS scenarios

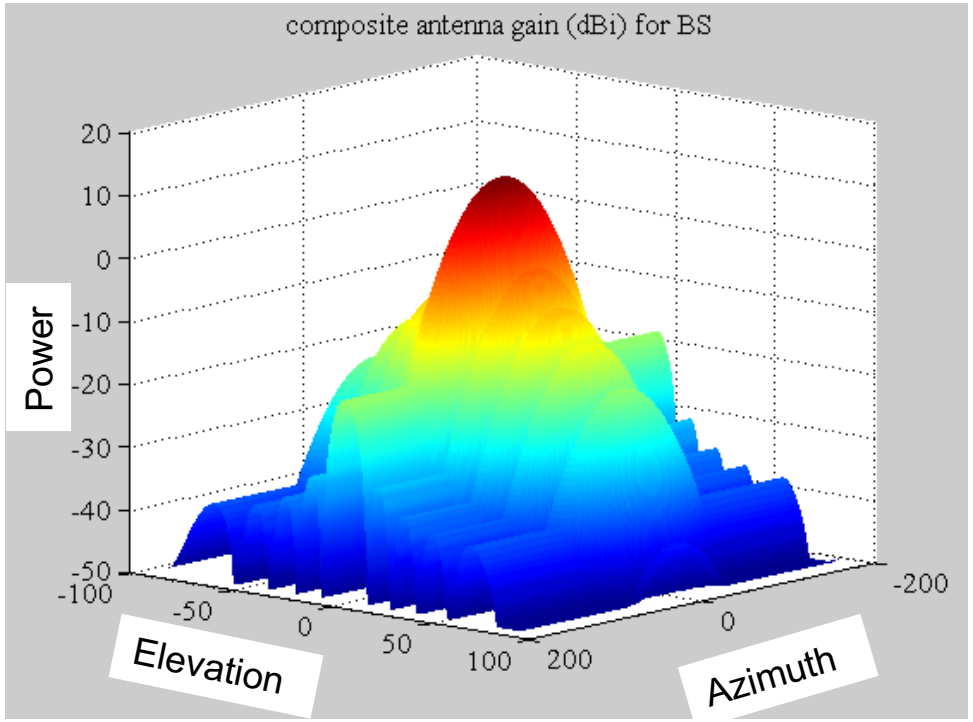
# Key Parameters (Simulation Approach)

| Parameter | Setting |
|---|---|
| Channel Bandwidth | 20 MHz |
| P2MP BS Antenna Height | 35 m |
| P2MP BS Transmit Power | 49 dBm (36 dBm/MHz) |
| P2MP BS Electronic Downtilt | 1 to 6 degrees |
| P2MP BS Locations | Hexagonal Grid |
| CPE Antenna Height | 7 m |
| CPE Transmit Power | 23 dBm (10 dBm/MHz) |
| CPE Locations | Random |
| FSS Earth Station Antenna Height | 5 m |
| P2MP BS Antenna Pattern[1] | 3GPP TR 36.873, v12.5.0, pp.17 |
| FSS Earth Station Antenna Pattern | 47 CFR 25.209(a)(1) |

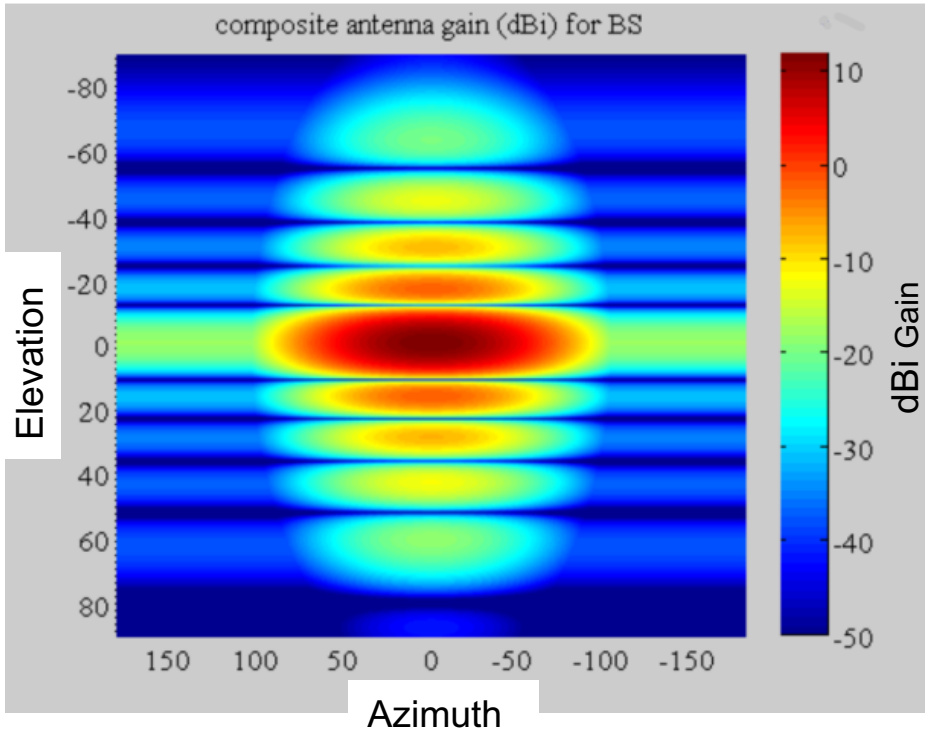
[1]Baseline 3GPP Models - S. Jaeckel, L. Rashkowski, K.Börner, L. Thiele, F. Burkhardt and E, Eberlein, “QuaDRiGa – Quasi Deterministic Radio Channel Generator, User Manual and Documentation”, Fraunhofer Heinrich Hertz Institute, Tech. Rep. v2.0.0.0,2017.

# P2MP BS Simulated Antenna Pattern

3D Antenna Pattern



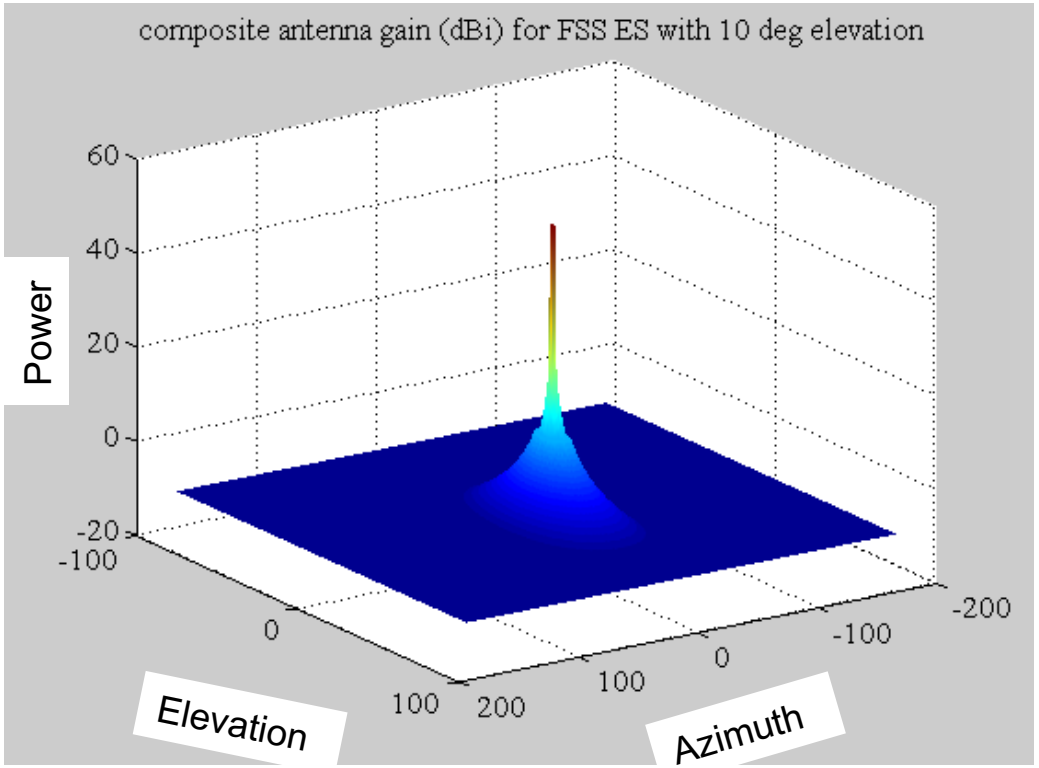

Look-Down 2D View



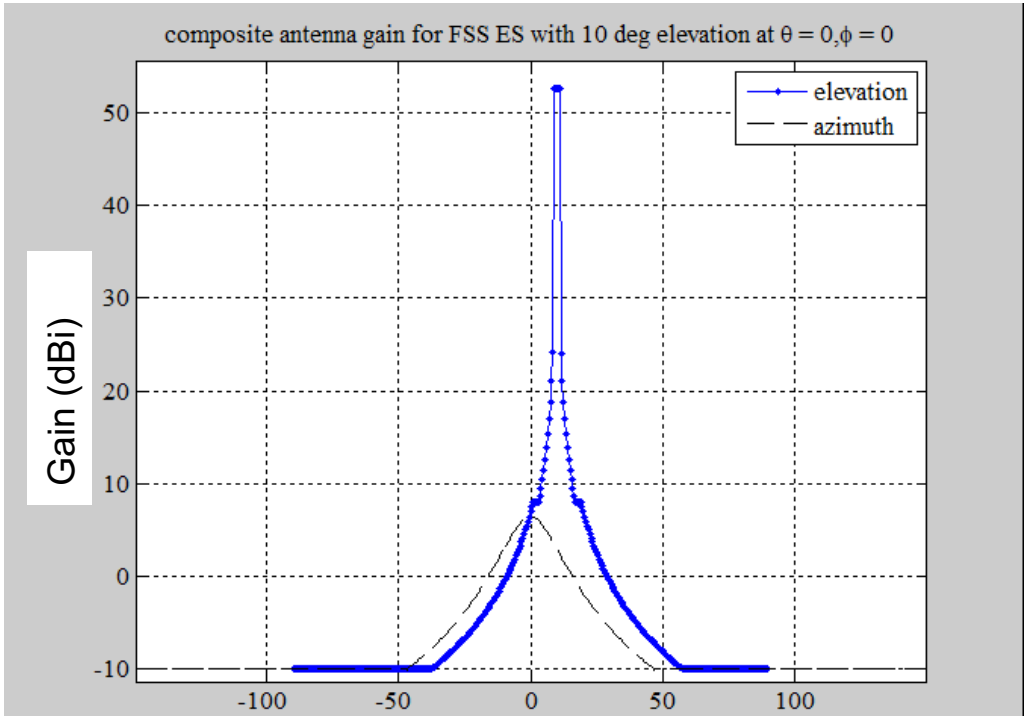

- 12 dBi Peak Antenna Gain
- Based on 3GPP TR 36.873

# FSS Earth Station Simulated Antenna Pattern

3D Antenna Pattern

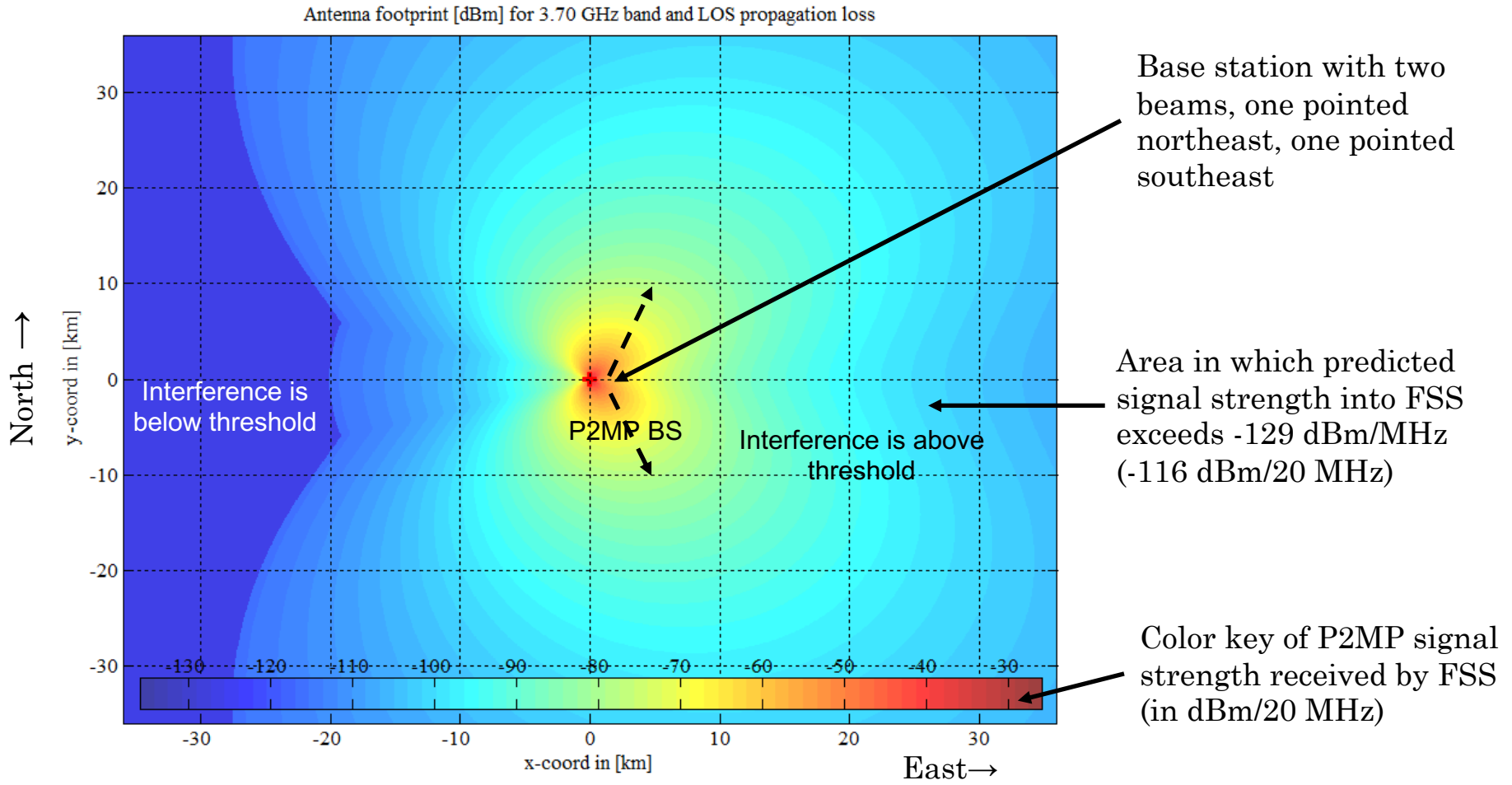



2D Gain Pattern



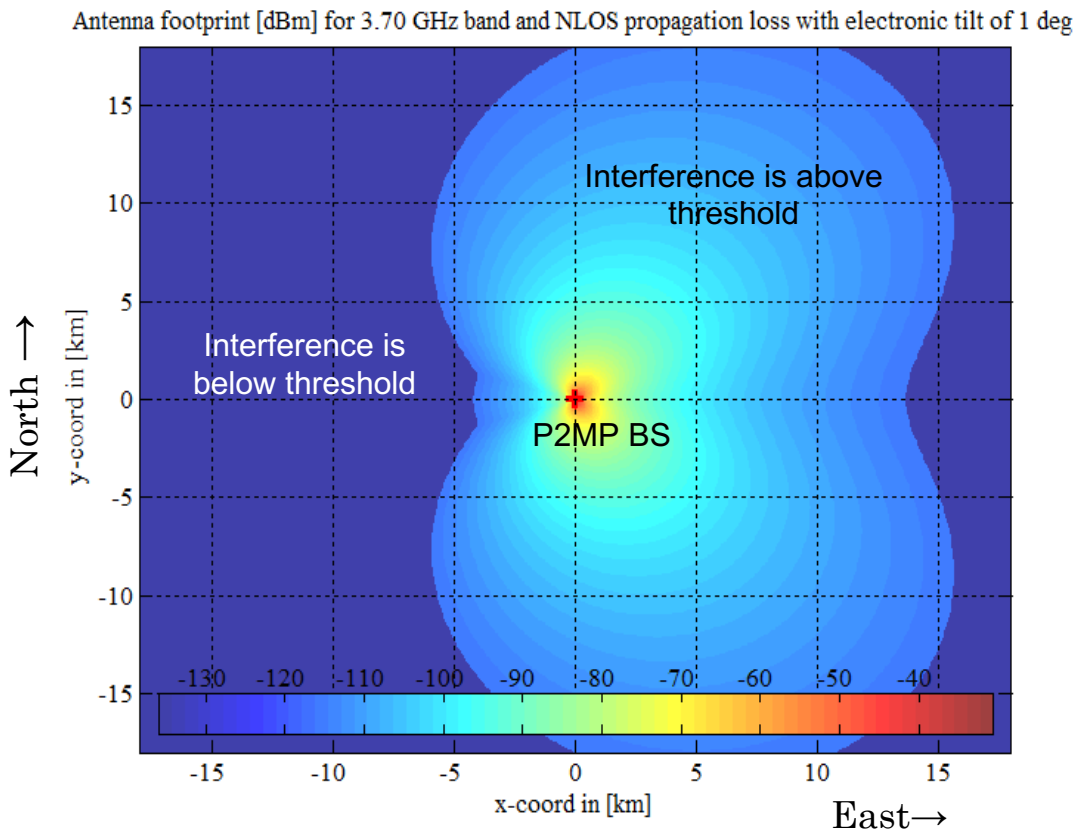

Angle from horizon point directly below boresight (degrees)

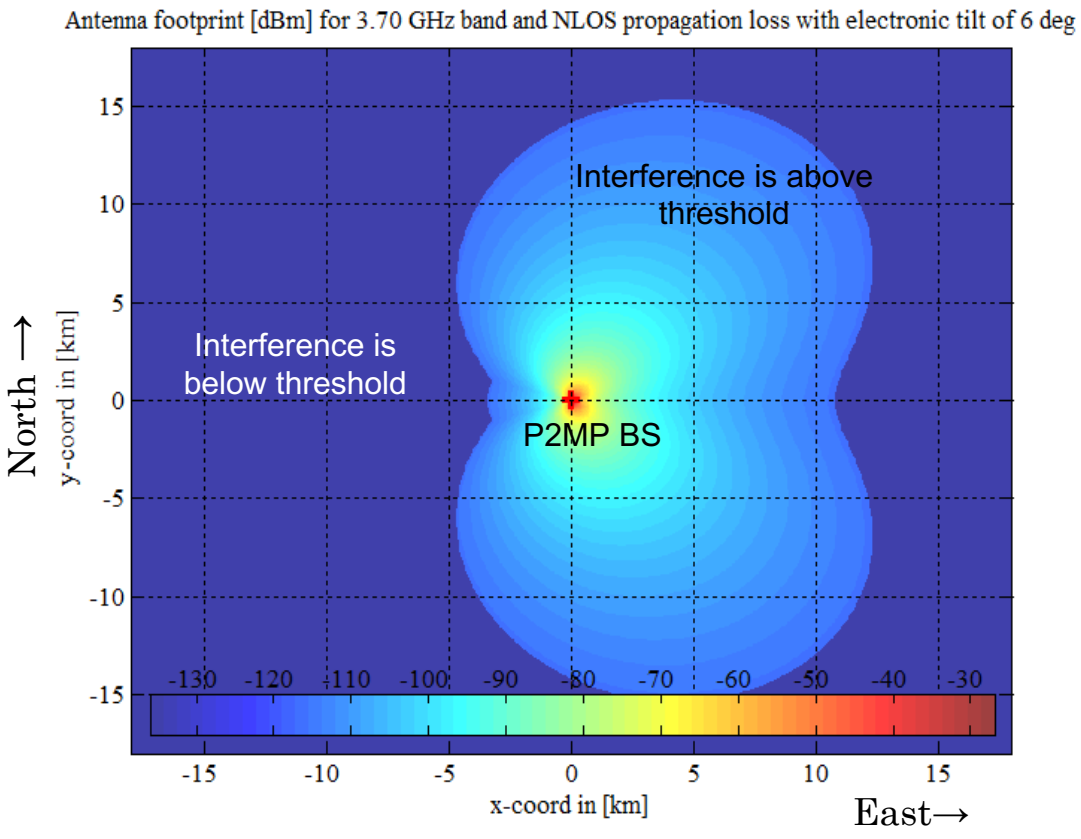
# BS Tx, LOS Propagation, 0 dBi sidelobe of FSS




- Highly conservative analysis based on Rural Macro *Line-of-Sight* propagation model, 0 dBi sidelobe of FSS earth station and P2MP BS antenna electronic downtilt of 1 degree
- Each point in the grid represents potential location of FSS earth station
- The received power at each point is calculated using arrival and departure angles between the transmitter and the receiver in 3-D coordinates

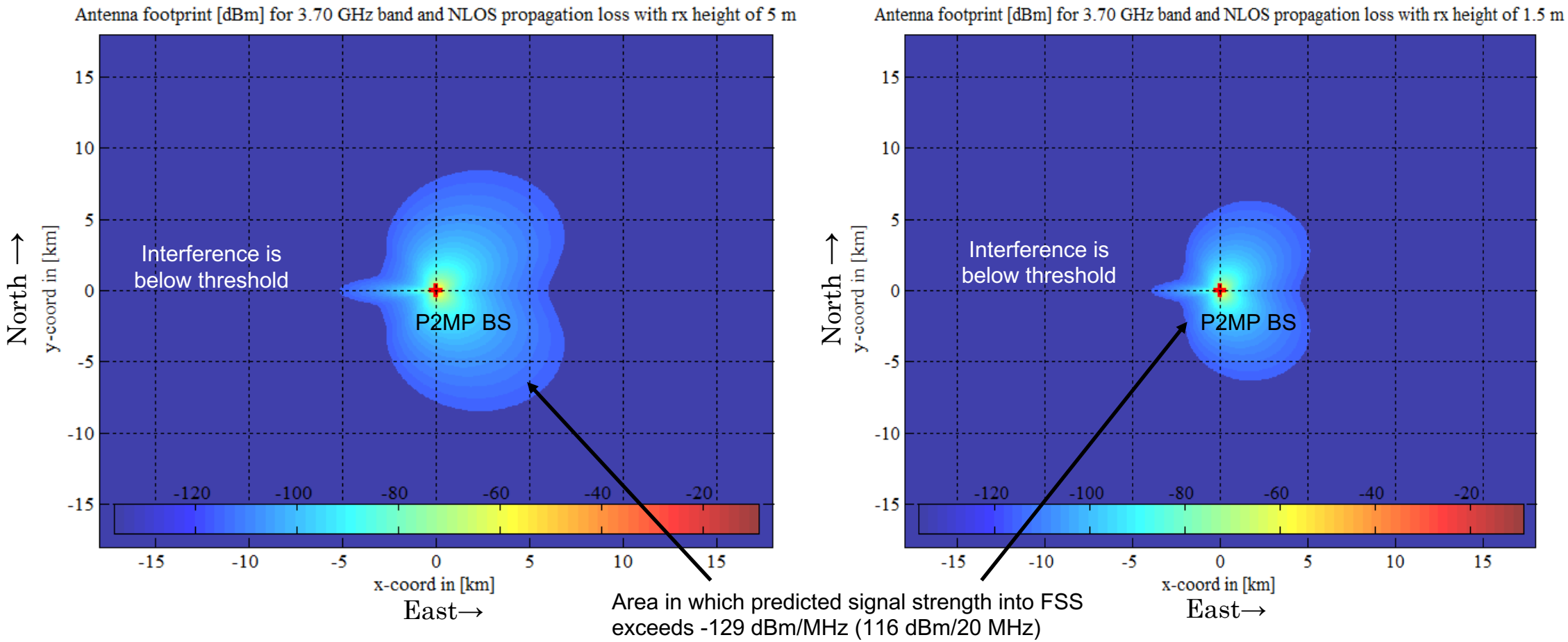
# BS Tx, NLOS Propagation, 0 dBi sidelobe of FSS



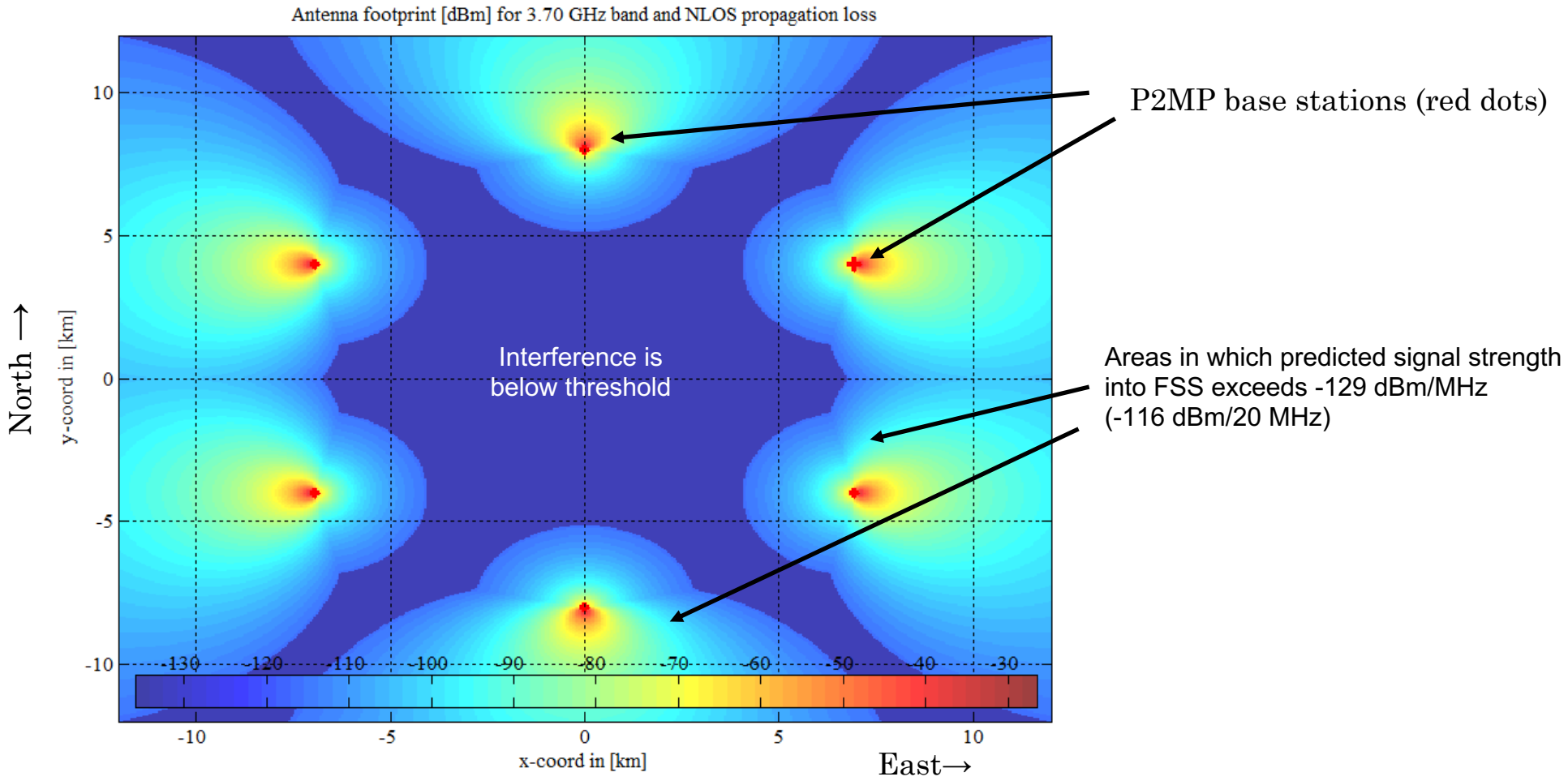

Analysis based on Rural Macro Non-Line-of-Sight (ITU-R M.2135) propagation model and 0 dBi sidelobe of FSS earth station

# BS Tx, NLOS Propagation, 25.209(a)(1) FSS pattern



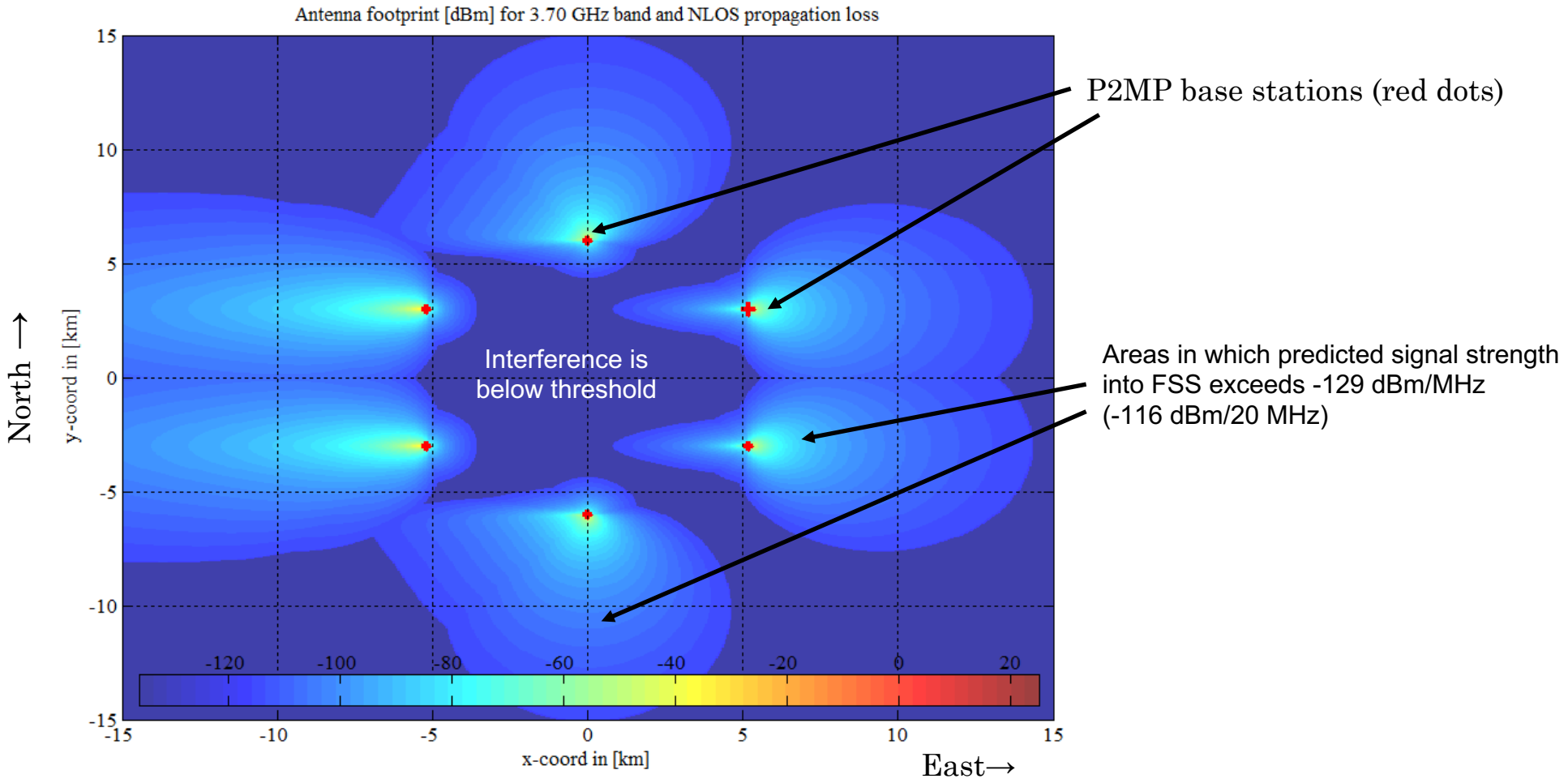

- Analysis based on Rural Macro Non-Line-of-Sight (ITU-R M.2135) propagation model with directional antenna pointing at 10 degrees elevation and 0 degrees azimuth (pointing due east/right)
- P2MP BS antenna electronic downtilt of 6 degrees and two FSS receiver heights (5 m and 1.5 m)
- Maximum exclusion zone : less than ~7 km

# Multiple BSs, NLOS Propagation, 0 dBi sidelobe of FSS



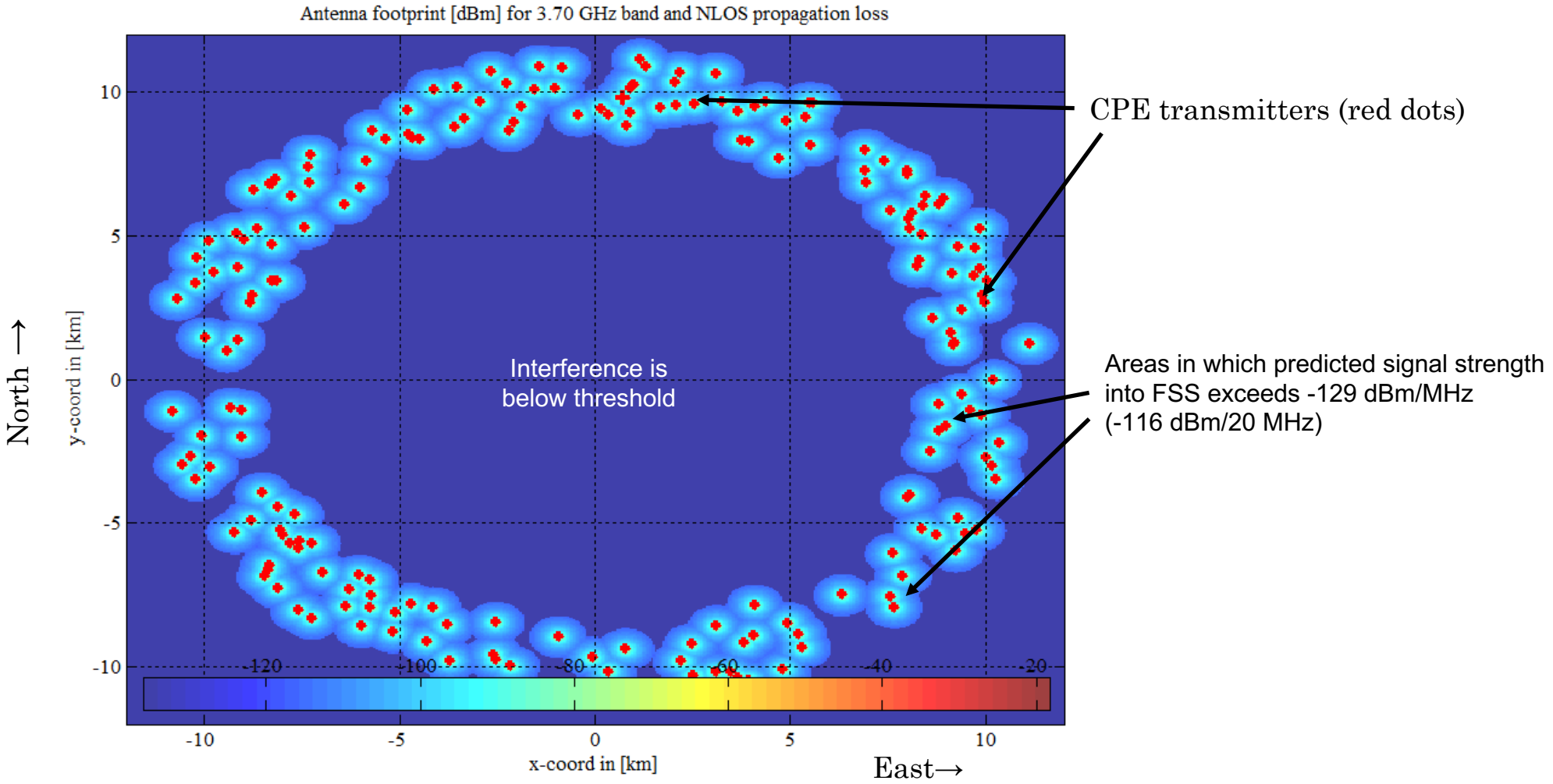

- Single sector illumination at all the transmit base stations that are arranged in a hexagonal grid, with the sectors pointing away from the center
- P2MP BS antenna electronic downtilt of 6 degrees

# Multiple BSs, NLOS Propagation, 25.209(a)(1) FSS pattern



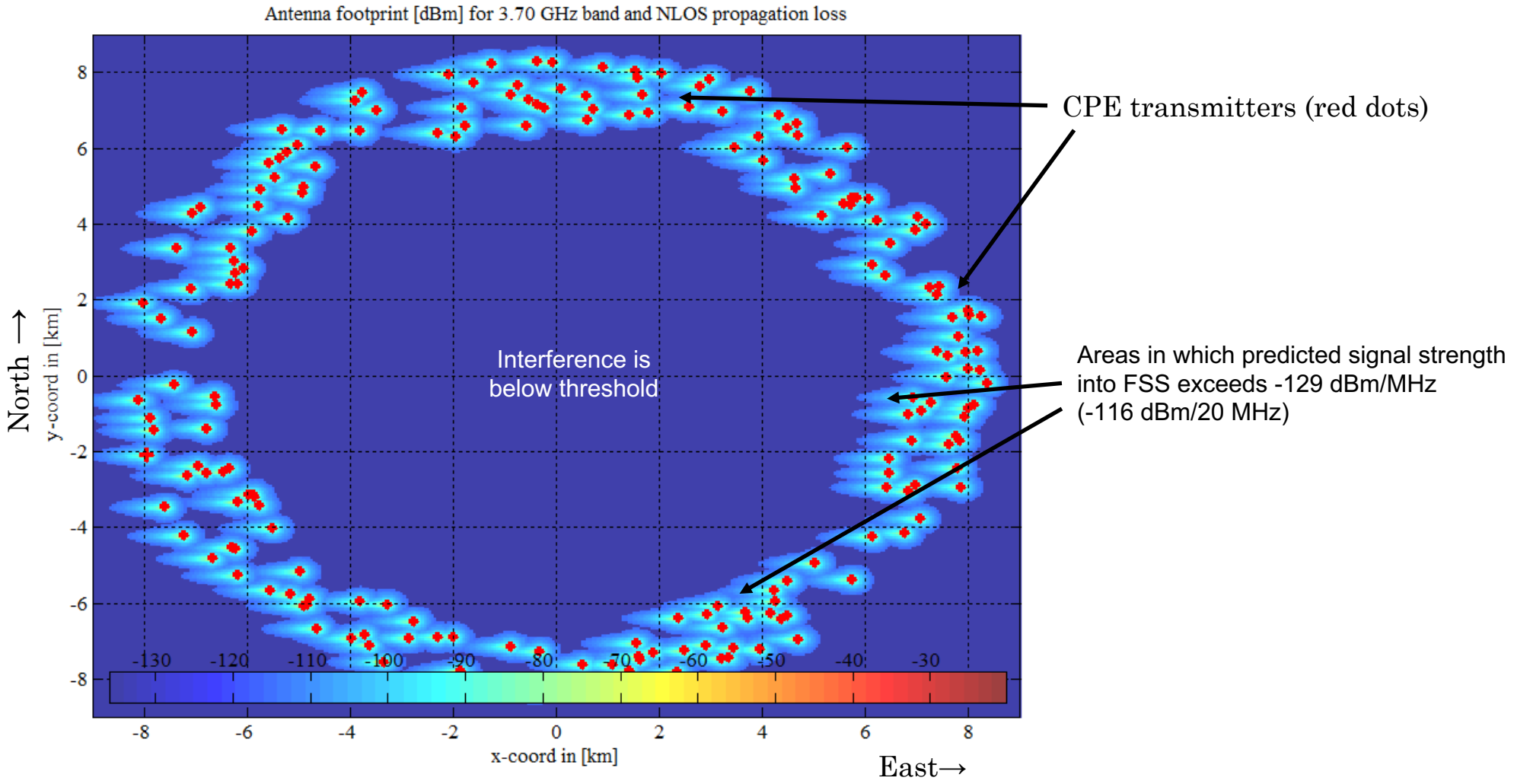

- FSS receive antenna gain pattern with elevation angle of 10 degrees and azimuth of 0 degrees (pointing due east)
- Single sector illumination at all the transmit base stations that are arranged in a hexagonal grid, with the sectors pointing away from the center
- P2MP BS antenna electronic downtilt of 6 degrees and maximum exclusion zone radius: less than ~7 km

# Multiple CPEs, NLOS Propagation, 0 dBi sidelobe of FSS




- CPE transmission has 0 dBi sidelobe towards FSS
- CPE distributed randomly in the region of analysis

# Multiple CPEs, NLOS Propagation, 25.209(a)(1) FSS pattern




- FSS receive antenna gain pattern with elevation angle of 10 degrees and azimuth of 0 degrees (pointing due east)
- CPEs distributed randomly and transmitting with 0 dBi sidelobe towards FSS earth station

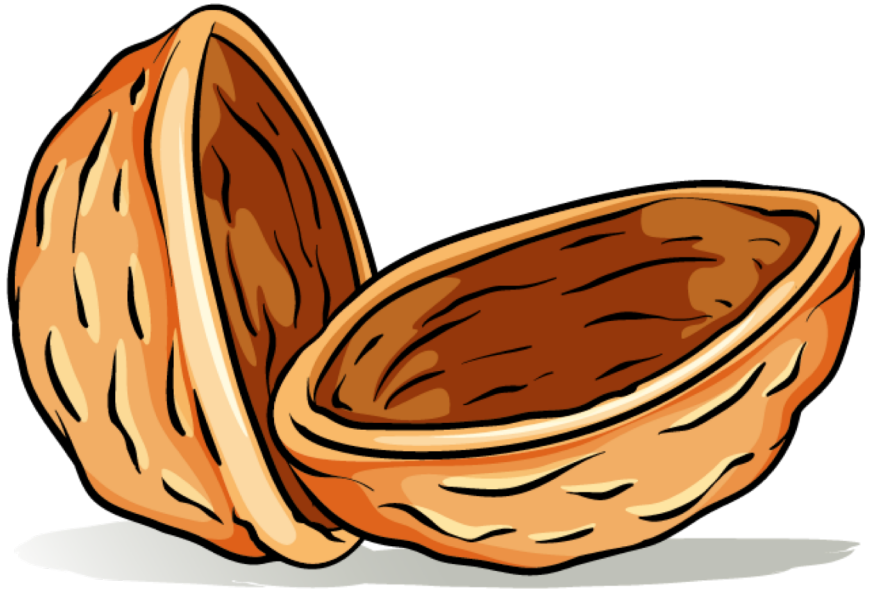
# Large-Scale Analysis: Refined Results

| Exclusion Zone Radius (km) | Potential P2MP Coverage (Refinement: Overlap between two Exclusion Zones considered) | |
|---|---|---|
| | P2MP Coverage Area (million square km) (U.S. Land Area: 7.7 M sq km) | P2MP Covered Pops (millions) (U.S. Population: 327 M) |
| 7 | 6.7 (87% of U.S. land area) | 131 (40% of U.S. population) |
| 10 | 6 (78% of U.S. land area) | 81 (25% of U.S. population) |

*Note*: Population assumed to be uniformly distributed within a county.

# Our Analysis is Conservative: Factors That will Shrink Exclusion Zones

- Non-fully-loaded P2MP BSs would transmit less power and cause less interference.
- Distribution of frequency resources ("Resource Blocks" or radio channels) among active CPEs in a sector would reduce power per MHz, because the CPE would distribute its transmit power among larger transmission bandwidths.
- Currently, only one sector of the P2MP BS toward the FSS receiver is turned off; in practice, more accurate network planning and design can be carried out to further reduce interference from fixed P2MP deployments.
- CPEs are assumed to be mounted at 7-10 m height. Real installations are often lower.
- Higher elevation pointing earth station dish would further reduce interference.
- If determined by coordination, the power levels of the BSs and the antenna height of the BS can be reduced to further restrict the amount of interference.
- Newer systems, including fixed 5G New Radio (5G NR), use narrower and device-specific beamforming even for non-traffic transmissions, further reducing interference compared to 4G blanket sector-wide transmissions.

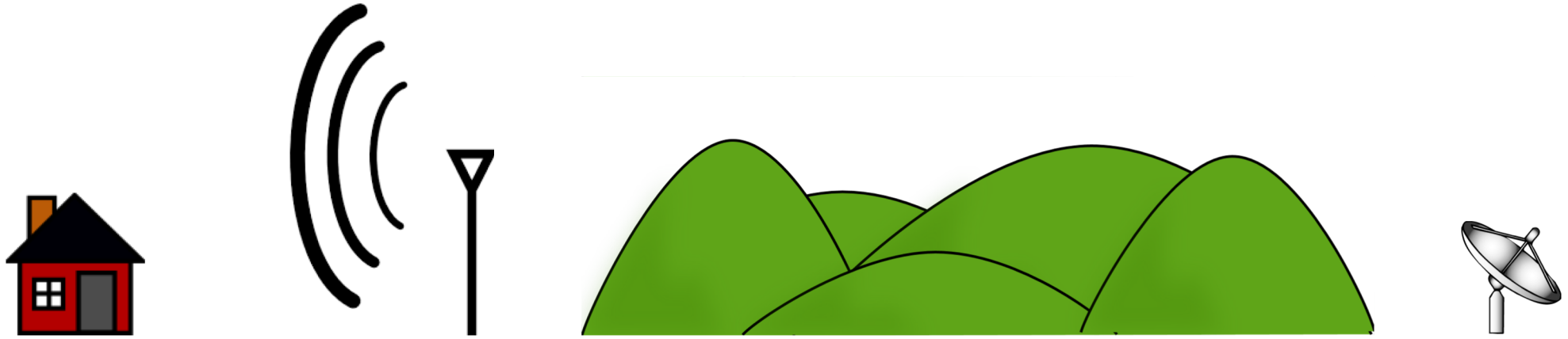


# 3.7-4.2 GHz Co-channel Coexistence in a Nutshell

# Summary & Conclusions

Exclusion zones of about 10 km are sufficient to protect most fixed-satellite service (FSS) earth stations from harmful interference caused by properly-engineered co-channel point-to-multipoint (P2MP) broadband systems.

P2MP systems operating outside the exclusion zones could provide gigabit broadband access to more than 80 million Americans, particularly those in underserved communities.



*Note:* the 10 km exclusion zone is a statistical average and is intended for the baseline performance and for estimating the national coverage. In practice, this would be a site-specific number determined by coordination and suitable RF planning and design.

# References


1. 3GPP, TR 38.901, “Study on channel model for frequencies from 0.5 to 100 GHz,” https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3173.
2. ITU-R M.2135-1, “Guidelines for evaluation of radio interface
3. technologies for IMT-Advanced,” December 2009, https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2135-1-2009-PDF-E.pdf.
4. ITU-R P.452-11, “Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above about 0.7 GHz,” 2003, https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.452-11-200304-S!!PDF-E.pdf .
5. United States Census Bureau, Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018,” https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2018_PEPANNRES&src=pt.
6. United States Census Bureau, “Population, Housing Units, Area, and Density: 2010 - State -- County / County Equivalent,” https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk .
7. FCC IBFS Database, https://licensing.fcc.gov/prod/ib/forms/index.html .